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Information Problem Solving: A Review of Problems Students Encounter and Instructional Solutions

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Abstract

Searching and processing information is a complex cognitive process that requires students to identify information needs, locate corresponding information sources, extract and organize relevant information from each source, and synthesize information from a variety of sources. This process is called information-problem solving (IPS). IPS can be characterized as a complex cognitive skill, which may need direct instruction to reach high levels of performance. However, IPS has been given little attention in schools, and instruction in this skill is rarely embedded in curricula. And yet, by giving students assignments in which students have to solve an information-based problem, teachers assume that their pupils have developed this skill naturally. A literature study was done to determine what kinds of problems students experience when solving information problems using the WWW for searching information, and what kind of instructional support can help to solve these problems. Results show that children, teenagers and adults have trouble with specifying search terms, judging search results and judging source and information. Regulating the search process is also problematic. Instruction designed specifically for IPS using the WWW for searching information is rare but indeed addresses the problematic skills. However, there are differences between various methods and it is unclear which method is most effective for specific age groups.

Information Problem Solving: A Review of Problems Students Encounter and Instructional Solutions

Our current society is an information society. Recent technological developments such as mobile communication, GPS, and the Internet provide us with large bodies of information every day. It is up to us to decide what to do with all this information. One could decide to ignore it altogether, but this will almost certainly result in alienation from society. A more fruitful approach might be to regularly gain access to new information. This approach requires people to identify their information needs, locate corresponding information sources, extract and organize relevant information from each source, and synthesize information from a variety of sources into cogent, productive uses (Bawden, 2001; Brand-Gruwel, Wopereis & Vermetten, 2005; Eisenberg & Berkowitz, 1990, 1992; Marchionini, 1999; Moore, 1995, 1997; Shapiro & Hughes, 1996; Spitzer, 2000). Together these activities constitute a process that we refer to as Information-Problem Solving (IPS).

IPS is not only important in everyday life, but also in education. In the last decade educational systems have undergone changes. Instead of a system aiming at the reproduction of knowledge, new learning is aiming at learning outcomes that are durable, flexible, functional, meaningful, and applicable. Active pedagogical methods, in which students learn by doing instead of listening and in which the teacher has a guiding role, fit this new learning (Simons, Van der Linden, & Duffy, 2000). Students are given assignments, such as writing an essay on Tibet, that require them to search for information. And although there are many other sources to search for information about Tibet (e.g. the library or an encyclopaedia) the most probable source a student would use nowadays is the World Wide Web (WWW) ("Jongeren checken internetinformatie zelden,", 2006) Assignments like the one mentioned above are common;

children in the early elementary grades are already confronted with it. However, little is known about how children, teenagers, and adults become proficient in solving information-based problems. It seems to be assumed that the IPS-skill develops spontaneously, that means, the skill receives little attention in schools and instruction is rarely embedded in curricula. It is, however, rather unlikely that students spontaneously develop a full-fletched IPS-skill. Research has shown that children, adolescents and adults have problems with IPS (Brand-Gruwel et al., 2005; Duijkers, Gulikers-Dinjens & Boshuizen, 2001; Hirsch, 1999; Kafai & Bates, 1997; MaKinster, Beghetto, & Plucker, 2002; Monereo, Fuentes, & Sànchez, 2000). Different age groups may, however, have different problems with IPS and hence benefit from different kinds of support. The goal of this article is to give an overview of the problems people of different ages encounter with solving information-based problems. After specifying these problems, a review of research addressing instructional methods for IPS is presented. Especially we want to answer the question whether and how these instructional methods foster problems students experience.

In this paper the Information Problem Solving while using Internet'-skill decomposition developed by Brand-Gruwel and Wopereis (2006) is used as an analytical framework. This decomposition, visualized in Figure 1, is based on empirical research findings regarding the IPS process of students who searched for information on the WWW and has been developed to support instructional designers. The skill decomposition defines IPS as consisting of five constituent skills: define information problem, search information, scan information, process information, and organize and present information. As can be seen, these constituent skills can be divided into sub skills. Furthermore, regulation is considered an important aspect in the entire search process. As the WWW is a comprehensive source of information, searching the WWW relies on peoples' regulative abilities. Regulatory aspects such as orientation, monitoring and steering play a key role in this process (Boekhorst, 2003; Brand-Gruwel, et al., 2005; Hill, 1999; Lazonder, 2003).

Insert Figure 1 about here

Imagine a 16-year old student, Rita. Rita has been given a very open assignment of writing an essay on Tibet. After reading this task, Rita does not have a fully defined information problem yet. *Defining the information problem* is important in order to get a clear insight into the problem (e.g. Hill,1999; Land & Greene, 2000; Moore, 1995). Rita asks herself the following questions: What should be the focus of the essay (e.g. government, nature, population or religion)? What questions must be answered? What knowledge do I already have on one (or all) of these subjects? This activation of prior knowledge helps Rita to integrate the new information found with old, known, information (Brand-Gruwel et al., 2005; Hill, 1999; Moore, 1995). Next, Rita should also pay attention to the task requirements, for instance is there a minimum or maximum number of pages specified for the essay, and what is the target audience? Once Rita has established all this, she can derive which information is needed and can start her search.

Rita has decided to write an essay on the government of Tibet, and enters the terms 'government + Tibet' in Google™. In the first three results she comes across a website by the Chinese government (http://www.chinese-embassy.org.uk/eng/zt/zgxz/default.htm) and two sites claiming to be the official website of the government in exile (http://www.**tibet**.net and http://www.tibet.com). Based on these results, she decides to open the second site, http://www.tibet.net. From previous experience she has learned that sites with a .com address are often commercial sites. She therefore expects the quality and reliability of the .net site to be higher. Quality and reliability are in this case criteria used to evaluate the found sources. During this *search for information* Rita has selected a search strategy (using a search engine), specified search terms and judged results. Computer skills like using a mouse and keyboard are also important in this part of the process (Brand-Gruwel et al., 2005; Marchionini, 1995; Sutcliffe & Ennis, 1998).

After opening the site http://www.tibet.net Rita discovers that this site is owned by the government in exile and the information is up to date. This site is useful for the essay and she copies some information in her own file. However, she decides that she needs more information on the Chinese view of the facts (Tibet has been occupied by China). She can take a look at her first result (http://www.chinese-embassy.org.uk/eng/zt/zgxz/default.htm) or do another search with keywords like Tibet + China. Rita has used the sub skills read information global, judge source and information, store relevant information and elaborate on content during this *scanning of information.*

After viewing the website http://www.chinese-embassy.org.uk/eng/zt/zgxz/default.htm for information, Rita finds that this is the website of the Chinese embassy in the United Kingdom. She decides that this is not very useful and searches Google with Tibet + China and opens the website www.**tibet-china**.org/indexE.html. This site gives a historic overview of Tibet and its relation with China, from Chinese perspective. Rita reads this site very carefully, and selects information that she can use in her essay. Reading the site carefully is part of the constituent skill *process information.* The goal is to reach a deep understanding of the information (Dochy, 1993; Schmeck & Geisler-Brenstein, 1989) and reaching an integration of the different pieces of information found and relevant prior knowledge so that the information problem can be solved (Wopereis, Brand-Gruwel & Vermetten, this issue).

Making the product as required in the task is the goal of the constituent skill *organize and present information.* Several products are possible: a presentation or a poster, or, as in our example, a text document such as an essay. For every type of product, it is important to formulate the problem. The layout must be determined and the components defined in this outline further structured and filled in. While organizing and presenting information elaboration remains important (Wopereis et al., this issue). Rita has found sufficient information to write her essay. First, she determines what the line of reasoning will be and structures the information found according to this line of reasoning.

As can be seen in the skill decomposition *regulation* activities will be carried out during the entire IPS process. Rita for example, was regulating when she decided she needed more information on the Chinese view. She compared the information found with her problem definition and decided that it was not enough to solve her information problem. Regulation is related to the effectiveness and efficiency of the entire process (Hill, 1999; Hill & Hannafin, 1997; Land & Greene, 2000; Marchionini, 1995; Lazonder, 2003).

Rita's IPS behavior we described here is very sophisticated. She has learned to execute all constituent and sub skills. By using Rita as an example we described an ideal rather than a real student. Research suggests that at least some skills are problematic for real students (e.g. Brand-Gruwel et al., 2005; Duijkers et al., 2001; Hirsch, 1999; Kafai & Bates, 1997; MaKinster et al., 2002; Monereo et al., 2000), but some years ago Rita herself might have had trouble with some sub skills too

The skill decomposition will be used to categorize the problems people have with IPS. These problems will be categorized for young children (age 6 till 12), teenagers (13 till 18) and adults (18 and older). Then, instructional solutions will be described in terms of their focus (i.e., the skills involved) and also the underlying didactical principles. The research questions addressed in this article are:

1) When people (of three age groups, 6-12, 13-18, 18+) experience problems with information-problem solving, under which constituent or sub skill of the complex cognitive IPS skill can these problems be placed?
2) What is the effect of different kinds of IPS instruction or support offered to these age groups and can instructional guidelines be deducted?

Method

Procedure

Selection: In order to find information on the difficulties people experience when solving information problems, PsycINFO and ERIC were searched with combinations of the following keywords: information (problems, - skills, - seeking, - searching, - literacy), WWW and Internet. The references of the articles found were used to search for new articles and books. Only articles in which an overview was given of problem areas and skills mastered by students were included in the overview.

Keywords used for gathering information about training, instruction or interventions concerning information-problem solving were combinations of: information skills, instruction, education, information problem solving, WWW, Internet. References were used for searching additional literature on this topic.

Articles dated before 1995 were excluded from the analysis because the rise of the World Wide Web started in 1995.

Analysis system: The IPS skill decomposition by Brand-Gruwel and Wopereis (2006) was used as analytical framework. Studies concerning problems students experience while solving information problems were categorized according to the constituent skills these problems pertain to. The studies on instructional methods were categorized by the addressed age group.

Results

Problems people encounter when solving information problems

The literature search resulted in fifteen studies. Table 1 provides an overview of the studies found.

Insert Table 1

Define information problem. The skill 'define information problem' is rarely included in information problem solving research. Only one study explicitly addressed this constituent skill (Brand-Gruwel et al., 2005), and three studies did not (Koot & Hoveijn, 2005; Lorenzen, 2002; Rosell-Aguilar, 2004). Other studies mentioned the task students had to solve and made some comments on the problem definition, but in these studies the focus was on the search itself (Bilal, 2000; Duijkers et al., 2001; Fidel, Davies, Douglass, Holder et al., 1999; Hirsch, 1999; Kafai & Bates, 1997; Large & Beheshti, 2000; Lyons, Hoffman, Krajcik & Soloway, 1997; Makinster et al., 2002; Monereo et al., 2000; Schacter, Chung & Dorr, 1998; Wallace, Kupperman, Krajcik & Soloway, 2000). Although defining the information problem is not the focus of these studies, some conclusions regarding this constituent skill can be drawn from their results. The sub skill 'read task' does not cause problems in any of the three age groups. Students in all of the studies seemed to understand the task and knew what was expected of them.

Brand-Gruwel et al. (2005) found that adults are capable of 'formulating questions' to define the problem. Teenagers on the other hand find formulating questions difficult (Lyons et al., 1997; Wallace, Kupperman et al., 2000). When teenagers had to search for information on the World Wide Web about a subject matter to accomplish a task, they had trouble with formulating useful inquiry questions. They often asked questions with a single correct answer instead of questions that required them to synthesize information from multiple sources. They asked a somewhat general question and tried to find information on it. When they could not find information to answer their question they simply changed the question. They adapted the question to available information found online and had troubles with posing good and rich questions.

‘Activating prior knowledge’, ‘clarifying task requirements’ and ‘determining needed information’ is also difficult for teenagers. Most teenagers start searching immediately without exploring the topic, planning the search or thinking about the task (Duijkers et al., 2001; Fidel et al., 1999; Lyons et al., 1997). Young children do not focus on the task either (Bilal, 2000), while adults do seem to activate prior knowledge (Brand-Gruwel et al., 2005; Monereo et al., 2000).

With regard to ‘clarifying task requirements’ something remarkable happened in the study by Wallace, Kupperman et al. (2000). Children seemed to entertain extra goals during their search that were not specified in the task. For instance, they tried to find the perfect Web page, to get a limited number of search results and find a ready-made answer to their question.

To conclude, it appears that adults do not have trouble with the constituent skill ‘defining the information problem’. Teenagers have trouble with ‘formulating questions’, ‘activating prior knowledge’, ‘clarifying task requirements’ and ‘determining needed info’. Little is known about young children and their problems with this constituent skill, but based on the problems teenagers have, we assume that the same problems occur with younger children.

Search information. All studies in this review address this part of the IPS-process. ‘Searching for information’ on the Web can be done in several ways. The three most common strategies are using search engines, entering URLs, and browsing subject categories. Young children are capable of browsing and following bookmarks; the other strategies are too difficult for them. Entering URLs becomes less problematic from the age of eight (Kafai & Bates, 1997). From the age of ten people are capable of using all strategies (Bilal, 2000; Brand-Gruwel,et al., 2005; Fidel et al., 1999; Kafai & Bates; Schacter et al., 1998).

The choice for a specific strategy depends on the problem at hand. Young children browse when the task is ill-defined (e.g. 'What should be done to reduce crime in California?'), and use a search engine with well-defined tasks (e.g. 'What are the three types of crime that happen most in California?'), although searching is difficult for them (Schacter et al., 1998). This results in a trial and error stratgy without a systematic approach (Koot & Hoveijn, 2005).

'Specifying search terms' is difficult for all age groups (Bilal, 2000; Kafai & Bates, 1997; Large & Beheshti, 2000; Lyons et al., 1997; Makinster et al., 2002; Schacter et al., 1998; Wallace, Kupperman et al., 2000). Young children often use full sentences instead of keywords (Bilal, 2000; Koot & Hoveijn, 2005; Schacter et al., 1998). Teenagers do not always know which search terms to employ, especially when multiple keywords are involved (Large & Beheshti, 2000). And when they do use multiple keywords, they often make their searches too broad, resulting in an overload of results (Duijkers et al., 2001).

In some studies involving adult searchers the groups investigated were subdivided into successful and unsuccessful searchers. Successful searchers used "well-composed keywords phrases and often put their keywords in quotes" (MaKinster et al., 2002, p.161). Unsuccessful searchers had more trouble finding the right keywords. Search success appeared to be strongly related to domain expertise. Students with more domain knowledge were more successful. Their domain knowledge helped them to specify better search terms and they were able to distinguish better between usable and non-usable sites. Novices had more trouble with understanding the structure of the information and did not know where to start the search (MaKinster et al.).

Monereo et al. (2000) also concluded that adults who were subject matter experts were better searchers than domain novices.

Another important sub skill is ‘judge search results’. Some young children are reluctant to read or scan the list of results (hitlist). They base their choice for opening a site on titles only (Kafai & Bates, 1997), while others rely heavily on the summaries describing the results (Hirsch, 1999; Koot & Hoveijn, 2005) or the rank in the hitlist (Koot & Hoveijn, 2005). In the studies of Lyons et al. (1997) and Wallace, Kupperman et al. (2000), young children judged the results based on the number of results their search produced. When only a few hits were generated by the search engine, they took this as a clue that the right answer was on one of those websites. Koot and Hoveijn (2005) also found that young children use a search engine as a magical machine, they expect the machine to provide them with the complete answer. Teenagers view every result without a clear evaluation of the results (Duijkers et al., 2001; Fidel et al., 1999).

Unsuccesful adult searchers do not evaluate results and the summaries, mostly because of a lack of domain knowledge. Like teenagers, the strategy chosen by unsuccesful adults was to inspect the search results in the order they were presented. Succesful adult searchers with considerable background knowledge evaluate results by looking at the title, the origin of the source, the description and useful information or identifiers in the URL such as “.edu” or “.com” (MaKinster et al., 2002).

In this phase of the process computer skills are determinative for the result of a search in young children (Kafai & Bates, 1997). This is different with adults. Adults with domain expertise but without computer skills solved the given problem in less time than adults without domain expertise but with computer skills (Monereo et al., 2000). Brand-Gruwel et al. (2005) also revealed that the way adults searched the WWW is more influenced by domain knowledge than by computer expertise. In their study, both experienced and novice adult Web-users searched the Web in a similar way on a task none of them was familiar with.

To conclude, most problems in the constituent skill ‘search information’ occur with sub skills ‘specify search terms’ and ‘judge search results’. Young children, teenagers and adults do not always know which search terms to use. Young children tend to use natural language or long sentences. The use of keywords improves with age, but only if domain knowledge is high. Adults with low domain knowledge lack the knowledge to come up with useful keywords and make their search too broad, resulting in an overload of hits. Moreover, judging the search results is not done systematically. People of all ages do not always open websites based on a valid judgement of the results. The source is not always questioned and the choice for opening a site is mostly guided by the title or summary of the site.

Scan information. After opening a Web site, the site will be scanned. When reading the information globally, young children and teenagers seem to be looking for exact matches to the answer they have in mind (Hirsch, 1999) and to be trying to find the perfect web page and a ready-made answer (Fidel et al., 1999; Lyons et al., 1997; Wallace, Kupperman et al., 2000). They scanned pages for the presence of pictures or read the first paragraph of a site to determine if it was worthwhile (Fidel et al., 1999; Hirsch, 1999; Kafai & Bates, 1997). Young children also tended to believe that everything that is posted on the Web is true (Hirsch, 1999; Schacter et al., 1998). Koot and Hoveijn (2005) found that young children say they trust the information they find, even if this information does not agree with their own experience. Relevance criteria mentioned most by young children are topicality, novelty and interest. Language (own vs foreign), authority and recency were hardly mentioned and young children did not actively consider the truthfulness, accuracy or validity of the information they found (Hirsch). Koot and

Hoveijn found that young children are aware of the fact that not all information on the WWW is true. However, they rarely check information from one site with another site, especially when the information agrees with prior knowledge. Judging is mostly done based on appearance, the length of the text and use of language (i.e. difficult words). When children are equipped with more knowledge of the Internet and WWW, they become more critical. They judge the owner of the site, look for up to date information and read more sites. However, the source and owner has to be recognizable or easy to spot. Children rarely actively search for the owner. Sources mentioned on the site are not checked either, and if there are more sites with the same information, the information is accepted as correct without further research.

Teenagers also have trouble separating reputable and questionable materials, and have problems with selecting and judging information (Duijkers et al., 2001; Lorenzen, 2002; Lyons et al., 1997). They use information that could answer their question, even if the site was from a commercial source and not intended for science assignments (Fidel et al., 1999). There is one study that exclusively focused on the sub skill of judging and selecting information of teenagers. Lorenzen interviewed 10th and 12th grade high school students to reveal how students are using the WWW to find information and how they evaluate the information. Results showed that students relied heavily on the search engine to distinguish good from bad sites. The criteria used by the students to evaluate a website and the information are the organization behind a page, the extension of the URL (.edu and .gov), the author and bibliography, whether the information was believable, spelling and grammar and the elaborateness of a site. These criteria seem rather advanced, but the students had trouble to formulate and apply them. It took the students much time to come up with criteria and they found it hard to express how they distinguished between good and bad sites. The criteria they mentioned were used too rigorously. For instance, they believed that the domain extensions guaranteed quality and they gave too much credence to the layout and elaborateness of a page. One of the students also rejected a good website because it had a spelling error. In fact, the spelling "error" was a British instead of American spelled word (honour versus honor). Furthermore, students do not seem to realize that the author of a site can be biased or that the authorship of a page is not always as advertised. So, teenagers use some criteria to evaluate web pages, but do not know how to use these criteria and how they can tell the difference between good and bad information (Lorenzen).

When asked which sources they use, adults in the study by Rosell-Aguilar (2004) said that they consult reliable sources like the university page, local newspapers and so on. They scanned a page thoroughly and followed links, using multiple sources of information. Monereo et al. (2000) reported that the majority of adult respondents to their questionnaire had great faith in the credibility of the information they had found. Results of Brand-Gruwel et al. (2005) revealed that adult expert searchers judged the quality and relevance of the information and the reliability of the sources more often than novice searchers did.

After judging source and information, relevant information should be stored. Young children do not record useful URLs or websites, resulting in trying to recreate good searches to return to previous sites (Hirsch, 1999; Large & Beheshti, 2000; Wallace, Kupperman et al., 2000). Schacter et al. (1998) found that young children did not bookmark many documents spontaneously. When they were explicitly asked to find at least three sources, they bookmarked more sites.

Children have the tendency to use the "Back" button to return to useful sites, instead of bookmarking (Fidel et al., 1999). It looks like young children and children do not store information and do not elaborate on content, but use the relevant information the first time they see it and integrate the scanning and processing phase. Furthermore, the expert adult searchers in the Brand-Gruwel et al. (2005) study spend more time on elaboration on content than the novices.

To conclude, the biggest problem while 'scanning information' is that judging is done based on expected information and not on aspects like validity, authority and recency. Most young searchers do not store relevant information. If a source seems useful after initial scanning, the site is read in depth and information is processed. They do not elaborate on content. Adult searchers seem to take the time to first scan and then process the information. In terms of the skill decomposition students of all age groups have problems with 'judging source and information'. Young children and teenagers also have problems with 'storing relevant information' and 'elaborating on content'.

Process information. Only five studies included results that concern the constituent skill 'process information'. Young children rarely take the time to read a site in-depth (Kafai & Bates, 1997; Schacter et al.,1998; Wallace, Kupperman, et al., 2000). They also tend to judge processed information by looking for words they expected to find. "They accepted the source as valuable if it contained those words, in some cases irrespective of the actual meaning of the page" (p.93, Wallace, Kupperman et al., 2000). Teenagers tended to do the same. In the study by Lyons et al. (1997) children used a commercial website to answer their question; they were unaware that the page only "applied to a specific product and was not necessarily the norm" (p. 21).

Young children do not store relevant information but modify text from the site in their own words and add it to their final product (Large & Beheshti, 2000). Wallace, Kupperman et al. (2000) state that some young children "never read enough of the page to understand that its content had nothing to do with their question, and they used it as evidence that they had finished their assignment" (p. 94).

From these few studies it can be concluded that young children do not read to understand the text in depth. '*Judging processed information*' seems to be a problem for young children and teenagers. Furthermore young children seem to have trouble with '*storing relevant information*'.

Moreover one can question if the difficulty with processing information spring from the fact that the Internet is made up with HyperText Markup Language (HTML), a language that allows documents to integrate references to other documents. Rouet and Levonen (1996) conclude that reading hypertext has benefits: extra information becomes easier to access in a hypertext environment. However, the risk of disorientation is higher and processing information in hypertext imposes a higher cognitive load on the users. Yet, providing users with structure and coherence cues can help overcome these problems (Rouet & Levonen).

Organize and present information. This constituent skill and its sub skills formulate problem, structure relevant information, outline the product, realize product and elaborate on content, is only mentioned in one of the thirteen studies. Brand-Gruwel et al. (2005) mentioned that experts and novice adults spent an equal amount of time on this phase, but experts paid more attention to the formulation and reformulation of the problem. In general, adults do not seem to have problems with this skill. In conclusion: organize and present information has not been described enough to point out which problems children, teenagers and adults may encounter. It can be stated that the way the information must be organized and presented in itself can be a complex cognitive skill. For instance, writing a scientific article is not an easy job. Research focusing on students' writing skills will probably give more insight in the problems students encounter with this skill.

Regulation. In six articles comments are made on regulation. Hirsch (1999) stated that young children "did not keep track of how they searched for information. They did not record useful URLs or keep a record of search queries” (p. 1271). Teenagers did not feel the need to plan a search or to check whether their planning was adequate (Fidel et al.,1999; Lyons et al., 1997). However, they did check their spelling in URLs and search terms and were aware of the fact that spelling can influence the results of a search (Fidel et al.)

Adults who can be categorized as strategic or successful searchers show signs of orientation, monitoring, steering and evaluating. Non-strategic searchers are less successful and do not regulate their search process (MaKinster et al., 2002; Monereo et al., 2000). Brand-Gruwel et al. (2005) stated that adult experts monitored and steered their process more often than novices.

To conclude: there is evidence that students in all age groups have problems with regulation. From the results it can be inferred that the quality of the IPS process is influenced by regulation. Children, teenagers and adults become better searchers when they orientate, test, monitor, steer and evaluate during the ongoing process.

Summary. This review of research focuses on problems people have with the different constituent and sub skills involved in the IPS-process. Table 2 gives a summary of the results.

Insert Table 2

The skills ‘searching’ and ‘scanning information’, haven been mostly addressed. The results show that the sub skills ‘specify search terms’ and ‘judge search results’ of the constituent skill ‘search information’ and the sub skill ‘judge source’ and ‘judge information’ of the constituent skill ‘scan information’ are a problem for all age groups.

It would be logical that instruction to foster students’ information problem solving ability should addresses the skills students have difficulties with. In the next part of this article we will discuss several instructional methods. Only empirically tested instruction and support is included in the overview.

Instructional solutions

The constituent and sub skills of the IPS process can cause problems for students of all age groups. The next question is: how can instruction support foster students to become more proficient in information problem solving? There are general instructional methods that focus on information problem solving with (electronic) library systems (e.g., Berner, McGowan, Hardin, Spooner, Raszka Jr. & Berkow, 2002; Eskola, 2005; Larkin & Pines, 2004; Todd, 1995; Wallace, Shorten & Crookes, 2000). The focus of these methods was mostly on the constituent skill search information, target groups were mostly children or adults. Although results of experimental groups were better than those of most control groups (e.g., Larkin & Pines; Todd; Wallace, Shorten, et al.), we did not use these studies in our review. As mentioned these instructional settings addressed searching within a specific system and not on the Web. Searching a library database and searching the Web appeal on different skills. For instance, the Web does not have an index or table of contents, and selecting the right keyword is therefore more important. Furthermore, the Web is much more extensive than a library database. The risk of wondering off is high and processing information is much more difficult.

A quote form Larkin and Pines points to another important difference, selecting and judging information is harder on the Web: “To ensure that they selected quality studies, the instructions required that they use the library databases (e.g., EBSCOhost, PsychInfo, etc.) and not Google or Yahoo” (p. 43). In our review therefore only empirically tested instructional methods for searching on the Web are included.

The results section will be organized by instruction for young children, teenagers and adults. In total 12 studies were found and will be analyzed (see Table 3).

Insert Table 3

Instruction and support for young children.

De Vries (this issue) created a task-related portal to support reflective web searching by elementary school children (fifth and sixth grade) while working on a collaborative task in the domain of biology. This portal was embedded in biology lessons. In the first design experiment, four elementary classrooms of different schools participated. Children worked in groups on a biology assignment for six lessons. They were asked to activate their prior knowledge. They used the portal (a web page with task-related categories and hyperlinks with meaningful names, indicating the content of the page) to answer their research questions. The children also received a worksheet on which they wrote down their own research questions, and, after they had completed their search, their answer. Results showed that this portal provided the children with too little structure.

The second experiment was conducted with two classrooms, with an adjusted portal. A hierarchy of main topics was added and a sitemap was provided. The hyperlinks were enriched with indications of the amount and sort of information that could be found. The worksheet was also slightly adjusted: children wrote down their research questions, their provisional answers and their final answers. The children worked in groups and formulated their answers together. This stimulated them to express their thoughts, reflect on findings on the web, and relate new information to prior experiences by talking about it. The results of this design-based research show that the portal helped them to find relevant websites and select useful information.

Hoffman, Wu, Krajcik and Soloway (2003) used a software program called Artemis to unravel the information seeking strategies of middle school students. Artemis provides students with a digital library to search and sort science information related to project-based investigations. Artemis only offers websites appropriate for school age children, selected and screened by librarians. "It helps students focus on the content of the on-line resource, evaluate its usefulness, and synthesize information rather than spending the majority of time simply locating appropriate sites on the WWW" (p.324). In this study, the authors "developed on-line and off-line learning materials to provide scaffolding, to support students' information-seeking activities as they asked question of interest, searched for information, assessed their findings, and created rich representations of their newly constructed understandings" (p. 324).

This posttest only study investigated the depth and accuracy of 16 sixth-grade students' content understandings as well as their use of search and assesses strategies as they used on-line resources via Artemis. Results showed that the depth of students understanding after working with Artemis varied. Most participants were able to articulate explanations and relations during an interview but these were only partially accurate. Some students could provide accurate understandings, but these were not very deep and often limited to recalling information. The results of the interviews were better than the products students delivered, the products "communicated a simple recall of factual information" (p. 336). The students who adequately engaged in inquiry strategies obtained more accurate understandings. These students thought about a number of possible search topics and were careful in the use of queries. They also showed selectivity in sources, deep navigation into sites, browsed the contents, and paused to read information related to their on-line inquiry. Students with better content understandings also used more complicated strategies to assess on-line resources. "They judged whether information was relevant to their driving question before investing time on a site. Decisions were based on a site's content rather than appearance or title. The majority of time was spent with worthwhile and understandable information; however, trustworthiness of the source was often based solely on the URL (e.g., .org, .com, .gov, .edu). Students were able to provide a limited critique of a site's appearance and content. Students with less content understandings were more likely to trust information, and judged relevancy based on appearance. Results show that students may benefit from the scaffolding features in Artemis and the off-line materials, but this is not true for all students and does not occur automatically.

In a part of a pilot study for a larger project concerning ways to improve the use of Internet for information location Pritchard and Cartwright (2004) asked 54 children (ages 10 and 11) to produce an information sheet about the history of bikes for children of their own age. Participants received a list of things they had to take into account when creating the sheet and a list of ten relevant websites. Before they were allowed on the Internet, they had to active prior knowledge through brainstorming with the teacher. The instruction consisted of a set of rules, examples of the use of the rules. Children could work on the assignment for two lessons. The rules were: 1) Keep any extract from the Internet short. 2) Make a comment about any extract you include. 3) Say where the information came from. The first two rules encouraged children to engage with the text, think about the extract and give it a context. They necessitated reading and making decisions about which part to select. The third rule helped to avoid unintentional plagiarism. There was no control group in this study. Results revealed that the end products were not optimal, "some children took extracts directly from a website and gave the impression of not having read the words which they were using" (p.28). Children had not engaged with the content in a meaningful way, although there was evidence that some children had composed their own text. Some children were able to use the rules and make comments on the sites, indicating "that they had considered the information and had gone beyond the information given" (p.30).

However, the support had little impact on the children's learning: children were not able to recall what they had learnt about bikes a week after they made the sheet.

Kuiper, Volman and Terwel (this issue) designed a curriculum for 5th graders to acquire Web skills. It was a multiple case study design in which four different schools participated. The knowledge domain of the curriculum was healthy food. The implemented curriculum consisted of eight weekly lessons of 1,5 tot 2 hours each. The first five lessons were aimed at developing Web searching, reading and evaluation skills. In the three last lessons, students received assignments and used the web to search for information and composed their own texts based on that information. Results showed that students' knowledge about Web skills improved. Students appeared to be inconsistent Web users, who did not always act upon their knowledge of web searching skills. Students showed unexpected, inconsistent or inflexible Web behavior and little planning and reflection.

To summarize, instruction for young children often combines a project on a certain topic with instruction on IPS, and can thus be categorized as embedded instruction. Collaborative instruction and discussions between students (De Vries et al., this issue; Hoffman et al., 2003; Kuiper et al., this issue) helps children become more engaged with the subject and information than individual instruction (Pritchard & Cartwright, 2004). Furthermore, three studies used computer based instruction (De Vries et al.; Hoffman et al.; Kuiper et al.), one study used paper materials (Pritchard & Cartwright, 2004).

Table 2 showed the problematic skills of young children. All instructional methods at least addressed the problematic skill 'judge source and information'. 'Formulate questions' is addressed by De Vries et al. (this issue). 'Activate prior knowledge' is addressed by De Vries et al. (this issue), and Pritchard and Cartwright (2004). All methods paid attention to the beginning of the search process by either addressing the sub skill 'formulate questions' (De Vries et al., this issue) or addressing the sub skill ‘specify search terms’ (Hoffman et al., 2003). Pritchard and Cartwright address ‘store relevant information’ and ‘elaborate on content’. The latter is also addressed by Hoffman et al. (2003). ‘Read in depth’ and ‘judge processed information’ is addressed by Kuiper et al. (this issue)

Problematic skills not addressed by these methods were: ‘clarify task requirements’, ‘determine needed info’, ‘judge search results’ and the constituent skill ‘regulation’.

These four studies do not use a pre test and control group in their designs. It can not be excluded that improvement of IPS skills, knowledge and rules is also caused by natural development and not only by instruction. Most studies have a large N, only the study by Hoffman et al. (2003) has an N lower than 20.

Instruction and support for teenagers. Britt and Aglinskas (2002) developed The Sourcer’s Apprentice, a computer application for teaching sourcing (identifying critical features of the source like author, author’s position, date, document type etc), contextualization (“identifying relevant features of a source that can be useful in creating a context for historical information”, p. 489) and corroboration (checking facts or interpretations from one source against other sources) in the context of researching a historical controversy. The Sourcer’s Apprentice provides students with several documents about a controversy and information about the documents such as author’s credentials and possible motives. After reading the documents students fill in note cards. The note cards allow students to fill in information about six source and three content features like author (who, position, how know and author motives) and document (when, type). After filling in the note cards, students receive a series of questions about the sources and contents of the documents and are asked to write an essay on the controversy.

A pre test-post test control group design with one experimental and one control group was used to test the Sourcer's Apprentice. The experiment was conducted twice, with different populations. 11^{th} grade students of two American history classes (N=15) and 11^{th} grade students of two economics classes (N=29). During the pre test, all participants were asked to read six documents centered on a controversy while taking notes. Then they received a question booklet, containing sourcing questions (e.g. "Which document was written earliest") and two essay questions. Next, the experimental group received a 2-day exposure to the Sourcer's Apprentice and a control group received 2 days of regular classroom activities on the module topic. Post test was the same as the pretest, but centered around a new controversy. Results showed that the experimental group outperformed the control group on the posttest; their sourcing skills had improved.

Duijkers et al. (2001) provided 28 teenagers (age 14) with a step-by-step plan to stimulate a critical look at sources and information. Participants in this case study worked in pairs. They had to choose 4 out of 20 sources to answer a research question. The step-by-step plan guided the children through the steps of thinking about criteria for sources and judging the sources on applicability to answer the research question. The sources had to be divided in three groups, usable, may be usable and not usable. Students had to explain why they put a source in a certain group. Four sources had to be chosen from the group with usable sources to answer the question. Participants stated that working with the step-by-step plan helped them to work more effectively and defend a choice for a specific source.

Lazonder (2001) instructed teenagers (mean age 14.2) in basic procedural skills and self-regulatory skills while searching the WWW. There were three instructional groups: a memory aid group, a timesharing group and a control group. The total number of participants was 168. All groups received materials on procedural skills (e.g., entering an URL, following hyperlinks).

The materials differed with regard to the instructional strategy to learn self-regulatory skills. The memory aid version included a diagram of the search process to introduce self-regulatory skills. The diagram was explained in the first chapter of the materials, prior to the procedural skills. Subsequent chapters only contained procedural skills instruction, though students were encouraged to use the diagram when following the instruction. Students could consult the diagram at will. In the timesharing version, the same regulatory skills were addressed. The skills were introduced in conformance with appearance in the search process. The instruction on regulatory skills was integrated with the procedural skills instruction. There was no diagram of the search process provided. The control group only received the procedural skills material. These procedural materials were identical to the material in the other groups. Each group attended for sessions of 50 minutes each. It was expected that students in memory aid and timesharing groups would outperform the students in the control group on Web search tasks and search tasks in an electronic database (OPAC task). The study used a 3X3 factorial design with three levels of instructional condition (memory aid, timesharing, control) and three levels of Web expertise (novice, beginner, intermediate). Results showed no performance gains of self-regulatory instruction. Students in all groups performed the same on the search tasks.

Gerjets and Schorr (this issue) designed and empirically evaluated a training program called CIS-WEB (**C**ompetent **I**nformation **S**earch in the World Wide **WEB**). The program was developed to improve pupils' (ages 12-13) processing of information in order to foster their ability to competently search for information on the WWW. CIS-WEB consists of six modules and is designed as an in-class training. The six modules aimed at basic knowledge about the Internet, the WWW and search systems in the web, information problems, structure of websites and use of web tools, evaluation with regard to credibility and actuality, segmentation of information problems and processing of the resulting sub tasks. Students listened to presentations, worked collaborative in an hypermedia environment and worked individually with paper and pencil materials like worksheets.

It was assumed that following the CIS-WEB program would result in an improvement of pupils' declarative knowledge of the Web and in better search performance. Furthermore, a stronger improvement was expected for pupils with higher engagement in the web training compared to those with lower engagement. 61 students participated. Data was gathered four times during the training. Declarative knowledge was measured with a multiple-choice test, search performance was measured by the way students solved sets of information problems. Results showed that CIS-WEB enhanced pupils´ declarative knowledge about the web and their search performance compared to the control group.

To summarize, instruction for teenagers is offered embedded (Britt & Aglinskas, 2002) as well as stand alone (Lazonder, 2001; Duijkers et al., 2001; Gerjets & Schorr, this issue). Student motivation and engagement seem to be important factors for improving IPS skills (Gerjets & Schorr, this issue). Only one instructional method for teenagers used a collaborative method (Duijkers et al.); the other methods were given to individual students (Britt & Aglinskas, 2002; Lazonder, 2001) or use collaborative and individual methods (Gerjets & Schorr, this issue). Two methods were 'paper en pencil' based (Duijkers et al.2001; Lazonder, 2001), the other two used computer based instruction materials (Britt & Aglinskas 2002; Gerjets & Schorr, this issue).

Table 2 showed the problematic skills of teenagers. Except for Lazonder (2001) all methods at least addressed the problematic sub skill 'judge source and information'. The instruction by Lazonder (ibid) is the only method addressing the constituent skill 'regulation'. 'Specify search terms' is addressed by Lazonder (ibid), and Gerjets and Schorr (this issue). The latter also addressed 'formulate questions'.

Problematic skills not addressed by these methods are ’activate prior knowledge’, ‘clarify task requirements’, ‘determine needed information’ and ‘judge search results’.

Three of four studies (Britt & Aglinskas, 2002; Lazonder, 2001; Gerjets & Schorr, this issue) use a design with a control group. The study by Duijkers et al. (2000) has a smaller N (28) than the other studies. Only Britt and Aglinskas (2002), and Gerjets and Schorr (this issue) use a pre test.

Instruction and support for adults. Colaric (2003) examined three instructional treatments to support adults in using a search engine, including specifying search terms. The three treatments, instruction by example (N=59), conceptual models without illustrations (N=61), and conceptual models with illustrations (N=56), were compared on differences in knowledge acquisition: declarative (understanding of factual information about a search engine), syntactic (understanding of the appropriate formulation of a search query) and semantic knowledge (understanding of the major objects and actions of a search engine). Pre-test and post-test were the same. Declarative knowledge was measured with questions on factual knowledge of search engines. Syntactic knowledge was measured by the elements of a search query with regard to a provided search problem. Semantic knowledge was measured by the participant’s explanation of how a search engine works. The three treatments were each given during one class period. Results reveal that all instructional treatments were effective for increasing the three types of knowledge. However, syntactic knowledge (which can be compared with specifying search term, a sub skill all age groups have problems with) increased most with instruction by example. This study was done with written material and did not involve actual searches on the Web.

In a study by Feddes, Vermetten, Brand-Gruwel and Wopereis (2003) adults received an IPS training. The training was based on the skills defined by Eisenberg and Berkowitz (1990).

During the pre- and posttest the participants (N=4) were given an information problem and were interviewed about how they would solve the problem. Results show changes in ‘problem definition’, ‘searching’, and ‘processing’. Participants gave more elaborate description of the latter two after the training. ‘Problem definition’ was almost absent in the pre-test and was mentioned by most participants after the training.

Stadtler, Bromme and Stahl (this issue) provided adults with little medical knowledge (N = 118) with evaluation and monitoring prompts while searching the WWW on a medical topic. For this purpose, the metacognitive tool met.a.ware was developed. This tool enabled users to store information they have found systematically. It provides them with different labelled tabs (ontological classification) under which they can store information. To test met.a.ware, participants received preselected websites on the topic of cholesterol. Participants (aged 19 to 38, mean age 23.81) received prompts to evaluate sources on credibility or assess how well they comprehended information and how much they still needed to search for more information. There were four experimental conditions. The difference between the experimental conditions was the type of prompts participants received. The evaluation group received evaluation prompts, the monitoring group received monitoring prompts, the evaluation and monitoring group received types of prompts and the no prompts group did not receive prompts. There were also two groups who did not work with met.a.ware. One of these control groups took notes with paper and pencil, the other used a text window to copy and paste information from the WWW into text slots. A pretest was administered to measure computer and Internet experience, as well as factual knowledge on cholesterol. After 40 minute of searching, participants repeated the test on factual knowledge and answered four questions on subject matter. The posttest also included an assessment on knowledge about sources and a rating of the credibility of websites.

Results showed that prompts for monitoring and evaluation increased knowledge on content and sources, and ontological classification helped to structure notes and focused participants on important ontological categories.

Wopereis et al. (this issue) compared a control group that did not receive instruction with an experimental group that received additional instruction on IPS integrated in professional distance education skill training (N=16). The aim of their study was “to find out what the effect of the integrated IPS instruction was on the way distance education students solve information problems” (p. 9). Adults in the experimental group were taught how to seek information efficiently. The emphasis of the training was on the regulation of the process. A pre-test post-test control group design was used. On the pre-test no differences were found with regard to prior knowledge on IPS and regulation ability. Results on the post-test differ somewhat between the two groups. The constituent skill ‘scan information’ and the sub skill ‘judging information’ were performed more by students of the experimental group. Participants in the experimental groups also monitored and steered their process more often. Time spent on defining the problem was low in both groups.

Almost all instructional methods for adults were offered as separate courses. Only the instruction provided by Wopereis et al. (this issue) was embedded in a curriculum. All described instructional methods for adults are individual. Adults seem to benefit from instruction that focuses on the process of IPS. When they receive instruction or examples on how to search effectively, their results on a task improve. Only Stadtler and Bromme (this issue) use computer based instruction.

Table 2 showed the problematic skills of adults. These are ‘specify search terms’, ‘judge search results’, ‘judge source and information’, and the constituent skill ‘regulation’. Colaric (2003) only addressed specify search terms. Feddes et al. (2003) and Wopereis et al. (this issue) addressed all constituent skills and sub skills. Stadler et al. (this issue) addressed the problematic sub skill ‘judge source and information’ and the constituent skill ‘regulation’.

Two studies use a control group (Stadtler et al., this issue; Wopereis et al., this issue) and all studies use a pre and post test. The study by Feddes et al. (2003) has a very small number of participants.

Summary

Table 4 gives an overview of the IPS instruction and support per age group.

Insert Table 4

Table 4 shows that five instructional methods are given embedded (Britt & Aglinskas, 2002; De Vries, this issue; Hoffman et al., 2003; Pritchard & Cartwright, 2004; Wopereis et al., this issue) and one partly embedded (Kuiper et al., this issue). Six methods are not embedded in a course or project (Colaric, 2003; Duikers et al., 2001; Feddes et al., 2001; Lazonder, 2001; Gerjets & Schorr, this issue; Stadler et al., this issue).

Four of the twelve discussed methods were given used collaborative instruction or assignments (De Vries, this issue; Duijkers et al., 2001; Hoffman et al., 2003; Kuiper et al., this issue). There other instructional methods were individual methods (Britt& Aglinskas, 2002; Colaric, 2003; Feddes et al., 2003; Lazonder, 2001; Pritchard & Cartwright, 2004; Gerjets & Schorr, this issue; Stadler et al., this issue; Wopereis et al., this issue).

Five out of twelve studies use a computer program for their instruction (Britt& Aglinskas, 2002; De Vries, this issue; Hoffman et al., 2003; Kuiper et al., this issue; Stadler et al., this issue), six studies use paper materials (Colaric, 2003; Duijkers et al., 2001; Feddes et al., 2003; Lazonder, 2001; Pritchard & Cartwright, 2004; Wopereis et al., this issue). One study combines computer materials with paper materials (Gerjets & Schorr, this issue).

The problematic sub skills for every age group are ‘specify search terms’, ‘judge search results’, ‘judge source and information’ and the constituent skill ‘regulation’. One or more of these skills are addressed in every instructional method.

Most of the instructional methods are effective. However, the evidence for this conclusion is not very strong due to methodological shortcomings. Only very few methods used a control group (Britt & Aglinskas, 2002; Lazonder, 2001; Gerjets & Schorr, this issue; Stadtler et al, this issue; Wopereis et al., this issue); and in only one occasion have the results of the instructional support been tested for transfer (Lazonder, 2001).

Some studies are only partly effective. In the studies by Pritchard and Cartwright (2004) children did not engage with content because they were focusing more on the mechanical aspects like navigating and cutting and pasting information. And although they did follow the instructed rules, their final products lacked quality. Pritchard and Cartwright state: “simple exposure to information or simple copying from one place to another does not imply learning” (p.30). The rules provided by Pritchard and Cartwright were not enough, children should also be encouraged to actively engage with the information. Differences in the active engagement in the inquiry process are also the reason for differences in acquired knowledge in the Hoffman et al. (2003) study.

The instructional method by Lazonder (2001) was not effective. One of the possible reasons is the time factor. Instruction time may have been too brief for regulation skills to develop.

Discussion

The goal of this literature study was to give an overview of the problems children, teenagers and adults encountered while solving information problems using the Web for searching information and of the effects of different kinds of instructional support to foster students' information problem solving ability.

It can be concluded that people in every age group experience some problems with IPS. Some constituent and sub skills are mastered during the process of growing up, other skills remain problematic throughout life. Children, teenagers and adults have problems with specifying search terms, judging search results, judging source and information and regulating their search process. Children and teenagers also have trouble with the constituent skills define information problem and process information. Instruction in IPS should therefore take into account the age of the target group and adjust the instruction accordingly.

The instructional and support methods reviewed in this article can be grouped based on several features: the way the instruction is offered (either embedded in the curriculum or as a separate course); the way the instruction is followed by participants (individually or collaboratively), tools used during the instruction, and the skills addressed in the instruction. The review shows that there are only a few empirically tested instructional or support methods for IPS. Most of the methods found were stand-alone courses for individual use. Tools used in these methods differ from a web-based portal or a computer application (Britt & Aglinskas, 2002; De Vries, this issue; Hoffman et al., 2003; Kuiper et al., this issue; Stadtler et al. this issue), to worked-out examples and visualizations (Gerjets & Schorr, this issue), to worksheets (Lazonder, 2001), to paper material only (Colaric, 2003; Duijkers et al., 2001, Feddes et al., 2003; Pritchard & Cartwright, 2004; Wopereis et al., this issue). It is promising that all methods aim at (some of) the problematic skills of their target group and that most of them are effective. However, the effectiveness of the methods has not been established without doubt. The first, and perhaps one of the biggest, question marks that can be placed by the instructional methods is the fact that only one of them (Lazonder, 2001) tested for transfer. Yes, most of the instructional methods were effective, but none of them were tested again after a certain amount of time and only one within a different context. It is not certain that the knowledge and skills participants gained during the instruction were embedded in long-term memory and can be called upon while solving new information problems.

Next, it remains unclear whether or not instruction in IPS should best be given embedded or stand-alone. Although results from library research point towards embedded instruction as being most effective (Larkin & Pines, 2004; Todd, 1995; Wallace, Shorten et al., 2000), stand alone methods in this review also have positive results. However, these results have not been compared to an embedded version of the instruction, and again, have not been tested for transfer.

Some researchers argue that skills that are highly regulative, as IPS, can be learned in specially designed courses, because the skills do not vary across disciplines (e.g., Paul, 1992). On the other hand, Brown (1997) stated that highly regulative skills must be taught embedded in a context of a specific subject matter, in such a way that transfer to other domains is possible. Brown points out the importance of using real-life problems, because it motivates and stimulates active involvement. Also research of Ten Dam and Volman (2004) reveals that stand alone programs stimulating skills that are highly regulative and make an appeal to students' critical thinking ability are not effective.

Another question concerning the design of IPS instruction is whether they should be given collaboratively or individually. Again, results are inconclusive. Most methods are for individual use. In the study by De Vries (this issue) the collaborative nature of the instruction was one of the reasons why sub skills 'formulate questions' and 'activate prior knowledge' improved. Collaboration also has a positive influence on regulation (Lazonder, 2005), one of the problematic areas in IPS. So a combination of individual and collaborative assignment seems a good instructional strategy.

Another issue concerns the tools used in instruction. Different kinds of tools are used in the reviewed research. It is hard to say which tools (paper and pencil, worksheet, computer tools,etc.) are most effective, because the setting, the characteristics of the students, and the objectives of the instructions must be taken into consideration.

An important issue when designing IPS instruction is the focus of the instruction. IPS-instruction should strive to encourage students to actively engage in the process and not only focus on the 'mechanical' aspects. This also implies that the whole process should be taken into account. This finding is confirmed in the literature on problem solving and the development of complex cognitive skills (Van Merrienboer, 1997). Students should work on whole tasks, which are authentic and comprehensive. These tasks require students to perform all the constituent skills that make up the whole complex skill during task performance.

Moreover, scaffolding students to improve regulation should be part of the instructional setting. To improve regulation, cognitive apprenticeship (Collins, Brown, & Newman, 1989) is an appealing approach. This approach focuses on specific methods for carrying out complex cognitive tasks in which regulation is important. Apprentices learn these methods through the combination of observation, guidance and practice, or, from the teacher's point of view, through modeling, coaching and fading. The student repeatedly observes 'the expert' explicitly executing (modeling) the target process. The 'model' hereby externalizes the usually implicit cognitive thinking processes. After observing, the student attempts to execute the process with guidance and help. A key aspect in the coaching process is the provision of scaffolding: support, in the form of reminders and help so that the student can approximate the execution of the entire cognitive task. Once students have grasped the skill to be learned, the teacher reduces support (fading), providing only limited hints. So, cognitive apprenticeship intends to bring out internal cognitive processes in the open. Students are taught to act in the same way as modelled by the teacher.

A form of scaffolding and fading is providing the novice students with a process-oriented worked example. A study by Van Gog, Paas and Van Meriënboer (2006) showed that novices who received a process-oriented worked example (the problem state, the end state, the solution steps that are to be taken to reach the end state and the strategic “how” and principled “why” information used in selecting the steps), performed better on a transfer task than novices who only received a conventional problem. However, after some time, the examples can cause a cognitive overload and should no longer be offered. It is therefore also necessary to adapt the instruction at the level of the students.

To conclude, students of all ages encounter problems with solving information problems. Aspects as deriving search term and evaluating sources and information are often problematic. Instructional support to foster students’ IPS skill is therefore essential. Research about instructional support does give ideas and guidelines for designing this kind of IPS support, like working with whole tasks and a focus on the whole process. However, further research should aim at the mentioned issues and should especially include transfer of the IPS skill.

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Table 2

Problematic Sub Skills per Age Group

	Constituent skills					
	Define information problem	**Search information**	**Scan information**	**Process information**	**Organize & present information**	**Regulation**
Children (6-12 year)	- Formulate questions - Activate prior knowledge - Clarify task requirements - Determine needed info	- Specify search terms - Judge search results	- Judge source and information - Store relevant information - Elaborate on content	- Read in depth - Judge processed information - Store relevant information	Undetermined	- Orientation - Testing - Monitoring - Steering - Evaluation
Teenagers (13-18 year)	- Formulate questions - Activate prior knowledge - Clarify task requirements - Determine needed info	- Specify search terms - Judge search results	- Judge source and information	- Judge processed information	Undetermined	- Orientation - Testing - Monitoring - Steering - Evaluation
Adults	No problematic skills	- Specify search terms - Judge search results	- Judge source and information	No problematic skills	Undetermined	- Orientation - Testing - Monitoring - Steering - Evaluation

Table 3

Studies on Support and Instructional Methods for IPS

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Table 4

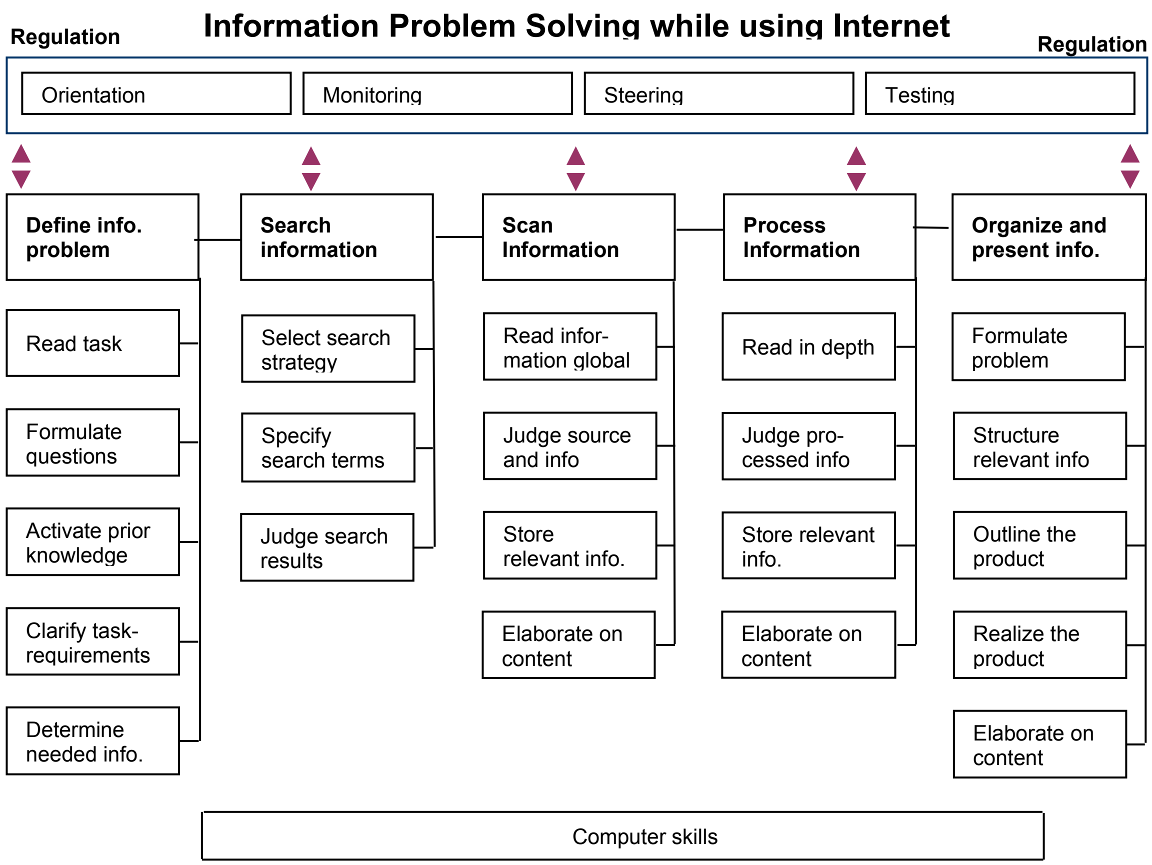
Support and Instructional Methods for IPS

Age group	Researchers	Instruction or support	Embedded or stand alone	Individual or collaborative	Constituent skill(s) addressed	Sub skill(s) specially addressed	Effective
Children (6-12 year)	De Vries (this issue)	Support	Embedded	Collaborative	- Define information problem	- Formulate questions - Activate prior knowledge - Judge source and information	Yes
	Pritchard & Cartwright (2004)	Support	Embedded	Individual	Define information problem Scan information Process information	-Activate prior knowledge - Judge source and information - Store relevant information -Eleborate on content	Partly
	Hoffman et al. (2003)	Support	Embedded	Collaborative	Search information Scan information Process information Organize and present information Regulation	- Specify search terms - Judge source and information -Realize product	Partly
	Kuiper et al. (this issue)	Support	Partly embedded	Collaborative	Search information Scan information Process information	- Select search strategy - Specify search terms - Judge search results -Read information global - Judge source and information -Elaborate on content -Read in depth - Judge processed information	Partly
Teenagers (13-18 year)	Britt & Aglinskas (2002)	Support	Embedded	Individual	- Scan information - Process information	- Judge source and information	Yes
	Duijkers et al. (2001)	Support	Stand alone	Collaborative	- Scan information - Process information	- Judge source and information	Yes
	Lazonder (2001)	Instruction	Stand alone	Individual	- Search information - Regulation	- Specify search terms - Orientation - Testing - Monitoring - Steering - Evaluation	No
	Schorr & Gerjets (this issue)	Instruction	Stand alone	Individual	Define information problem - Search information	- Formulate questions - Specify search terms - Judge source and information	Yes

					- Scan information - Process information		
Adults	Colaric (2003)	Instruction	Stand alone	Individual	- Search information	- Specify search terms	Yes
	Feddes et al. (2001)	Instruction	Stand alone	Individual	- All constituent skills	- All sub skills	Yes
	Stadtler et al. (this issue)	Support	Stand alone	Individual	- Scan information - Process information - Regulation	- Judge source and information - Orientation - Testing - Monitoring - Steering - Evaluation	Yes
	Wopereis et al. (this issue)	Instruction	Embedded	Individual	-All constituent skills, emphasis on regulation	- All sub skills	Yes

Figure captions

Figure 1. The Information Problem Solving Skill Decomposition (based on Brand-Gruwel, et al., 2005).


Information Problem Solving while using Internet
Regulation
Regulation
Orientation
Monitoring
Steering
Testing
Define info. problem
Read task
Formulate questions
Activate prior knowledge
Clarify task-requirements
Determine needed info.
Search information
Select search strategy
Specify search terms
Judge search results
Scan Information
Read infor-mation global
Judge source and info
Store relevant info.
Elaborate on content
Process Information
Read in depth
Judge pro-cessed info
Store relevant info.
Elaborate on content
Organize and present info.
Formulate problem
Structure relevant info
Outline the product
Realize the product
Elaborate on content
Computer skills